

Claims

What is claimed:

1. An apparatus for generating a write current for a magnetic memory cell comprising:
 - a write current generator for generating a write current, the write current being magnetically coupled to the magnetic memory cell;
 - at least one test magnetic memory cell, the write current being magnetically coupled to the at least one test magnetic memory cell; wherein
 - a switching response of the at least one test magnetic memory cell determines a magnitude of the write current generated by the write current generator.
2. The apparatus for generating a write current of claim 1, wherein the write current being magnetically coupled to the at least one test magnetic memory cell comprises a continuous series of pulses, in which the pulses alternate in polarity.
3. The apparatus for generating a write current of claim 1, further comprising
 - a test magnetic memory cell state detector for detecting a logical state of the at least one test magnetic memory cell, an output of the test magnetic memory cell state detector being fed back to the write current generator.
4. The apparatus for generating a write current of claim 1, wherein the write current generator comprises an easy axis write current and a hard axis write current.
5. The apparatus for generating a write current of claim 1, wherein the at least one test magnetic memory cell comprises two test magnetic memory cells, reference layers of the two test magnetic memory cells being oriented in opposite directions.
6. The apparatus for generating a write current of claim 4, wherein the write current is at least partially determined by setting the hard axis write current to a default value, and

incrementing the easy axis write current until at least one magnetic memory cell switches magnetic orientations, and storing Ieasy1 current value.

7. The apparatus for generating a write current of claim 4, wherein the write current is at least partially determined by setting the hard axis write current to a zero value, and incrementing the easy axis write current until at least one magnetic memory cell switches magnetic orientations, and storing Ieasy2 current value.
8. The apparatus for generating a write current of claim 6, wherein the write current is at least partially determined by setting the hard axis write current to a zero value, and incrementing the easy axis write current until at least one magnetic memory cell switches magnetic orientations, and storing Ieasy2 current value.
9. The apparatus for generating a write current of claim 8, wherein the write current is at least partially determined by averaging the values of the Ieasy1 current value and the Ieasy2 current value.
10. The apparatus for generating a write current of claim 4, wherein the write current is monitored over time.
11. The apparatus for generating a write current of claim 10, wherein monitoring the write current comprises periodically re-calibrating the write current, wherein re-calibrating the write current comprises:
 - subtracting a delta current from the easy axis write current while maintaining the hard axis write current at a default value;
 - verifying that the write current is still adequate for switching the at least one test magnetic memory cell; and
 - if the write current is not adequate to switch the at least one test magnetic memory cell, then incrementing the easy axis write current until the write current is adequate to switching the at least one test magnetic memory cell; and

adding the delta current back to the incremented easy axis current to obtain the re-calibrated write current.

12. The apparatus for generating a write current of claim 10, wherein monitoring the write current comprises periodically re-calibrating the write current, wherein re-calibrating the write current comprises:

adding a delta current to the easy axis write current while zeroing the hard axis write current;

verifying that the write current does not switch the at least one test magnetic memory cell; and

if the write current does switch the at least one test magnetic memory cell, then decrement the easy axis write current until the write current does not switch the at least one test magnetic memory cell; and

subtracting the delta current from the decremented easy axis write current to obtain the re-calibrated write current.

13. The apparatus for generating a write current of claim 10, wherein the write current is re-calibrated upon detection of a predetermined variation in a temperature of the apparatus.

14. A method for determining a write current for a magnetic memory cell, comprising:

supplying a test write current to a test magnetic memory cell;

sensing a magnetic state of the test magnetic memory cell to determine a switching response of the test magnetic memory cell; and

generating the write current having a magnitude that is dependent upon the switching response.

15. The method for determining a write current for a magnetic memory cell of claim 14, wherein the write current generator includes an easy axis write current and a hard axis write current.

16. The method for determining a write current for a magnetic memory cell of claim 15, wherein the write current is at least partially determined by setting the hard axis write current to a default value, and incrementing the easy axis write current until at least one magnetic memory cell switches magnetic orientations, and storing I_{easy1} current value.
17. The method for determining a write current for a magnetic memory cell of claim 16, wherein the write current is at least partially determined by setting the hard axis write current to a zero value, and incrementing the easy axis write current until at least one magnetic memory cell switches magnetic orientations, and storing I_{easy2} current value
18. The method for determining a write current for a magnetic memory cell of claim 17, wherein the write current is at least partially determined by averaging the values of the I_{easy1} current value and the I_{easy2} current value.
19. The method for determining a write current for a magnetic memory cell of claim 14, wherein the write current is monitored over time.
20. The method for determining a write current for a magnetic memory cell of claim 19, wherein monitoring the write current comprises periodically re-calibrating the write current, wherein re-calibrating the write current comprises:
 - subtracting a delta current from the easy axis write current while maintaining the hard axis write current at a default value;
 - verifying that the write current is still adequate for switching the at least one test magnetic memory cell;
 - if the write current is not adequate to switch the at least one test magnetic memory cell, then incrementing the easy axis write current until the write current is adequate to switching the at least one test magnetic memory cell; and
 - adding the delta current back to the incremented easy axis current to obtain the re-calibrated write current.

21. The method for determining a write current for a magnetic memory cell of claim 19, wherein monitoring the write current comprises periodically re-calibrating the write current, wherein re-calibrating the write current comprises:

 adding a delta current to the easy axis write current while zeroing the hard axis write current;

 verifying that the write current does not switch the at least one test magnetic memory cell;

 if the write current does switch the at least one test magnetic memory cell, then decrement the easy axis write current until the write current does not switch the at least one test magnetic memory cell; and

 subtracting the delta current from the decremented easy axis write current to obtain the re-calibrated write current.

22. The method for determining a write current for a magnetic memory cell of claim 14, wherein the write current is re-determined upon detection of a predetermined variation in a temperature of the apparatus.

23. An array of magnetic memory cells, the array comprising an apparatus for generating a write current for writing to the magnetic memory cells, the apparatus comprising:

 a write current generator for generating a write current, the write current being magnetically coupled to the magnetic memory cell;

 at least one test magnetic memory cell, the write current being magnetically coupled to the at least one test magnetic memory cell; wherein

 a switching response of the at least one test magnetic memory cell determines a magnitude of the write current generated by the write current generator.

24. A computing system comprising a central processing unit, and magnetic memory electronically connected to the central processing unit, the magnetic memory comprising an array of magnetic memory cells, the array comprising an apparatus for

generating a write current for writing to the magnetic memory cells, the apparatus comprising:

- a write current generator for generating a write current, the write current being magnetically coupled to the magnetic memory cell;
- at least one test magnetic memory cell, the write current being magnetically coupled to the at least one test magnetic memory cell; wherein a switching response of the at least one test magnetic memory cell determines a magnitude of the write current generated by the write current generator.